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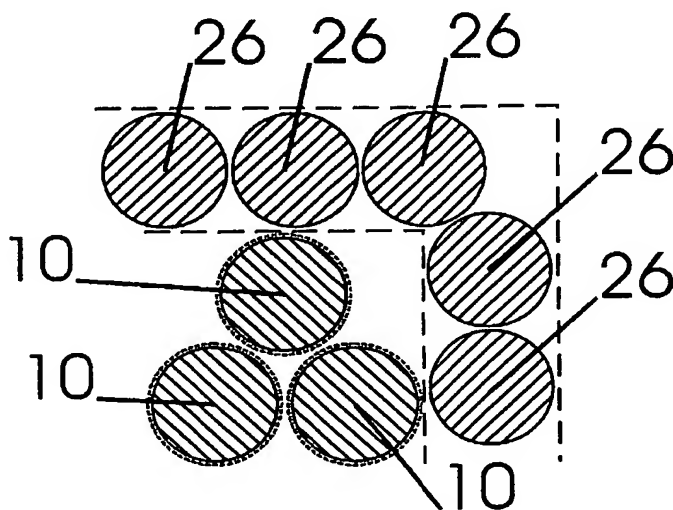
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(54) Title: **STEEL CORD FOR REINFORCING RUBBER ARTICLES**



(57) Abstract: A steel cord (38) comprises a first group and a second group. The second group is helically twisted around the first group with a cord twisting step. The first group comprises a first number of first steel filaments (10). The first number ranges between three and eight. The second group comprises a second number of second steel filaments (26). The second number is equal to or greater than the first number. The first filaments (10) having a twisting step greater than 300 mm. At least one of the second filaments (26) is polygonally preformed in order to allow rubber penetration.

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STEEL CORD FOR REINFORCING RUBBER ARTICLES

Field of the invention.

5 The present invention relates to a steel cord comprising a first group of first steel filaments and a second group of second steel filaments. The second group is helically twisted around the first group.

Background of the invention.

10 Steel cords with twisted steel filaments are known in the art, particularly in the art of rubber reinforcement, and more particularly in the art of tire reinforcement.

A 3+9+15 steel cord has been and still is a widely used steel cord, used amongs others, to reinforce the breaker or belt layers of truck tires.

An example of this 3+9+15 cord is following construction :

15 - 3x0.22 + 9x0.22 + 15x0.22 + 0.15 6.3/12.5/18/3.5 S/S/Z/S

Notwithstanding this widely spread use, this 3+9+15 cord has a number of drawbacks.

20 A first drawback is that the way of manufacturing such a 3+9+15 cord is not economical. Indeed at least two to four different twisting steps are required to manufacture the final cord.

In a first step, the three core filaments must be twisted. In a second step, the nine intermediate layer filaments are twisted around the core
25 filaments. In a third step the fifteen outer layer filaments are twisted around the intermediate layer filaments. As a fourth step, an additional filament is wrapped around the cord.

In the usual embodiments of a 3+9+15 cord, the two different twisting directions, S and Z, are used in order to reach a torsion balance in the
30 cord. In the examples given hereabove, the three core filaments and the nine intermediate layer filaments have been twisted in the S-direction and the fifteen outer layer filaments have been twisted in the Z-direction.

If a double-twisting apparatus is used in all the steps to manufacture such a cord, this means that the subsequent twisting in Z-direction of the
35 fifteen outer filaments partially untwists the earlier given twists in S-

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direction. This means a loss of energy during the manufacturing and accentuates again the non-economical way of manufacturing such a 3+9+15 cord.

5 A second drawback is that a 3+9+15 steel cord has no full rubber penetration. As a consequence humidity may reach the individual steel filaments during use, which may drastically decrease the life time of the steel cord and of the reinforced tire.

10 Numerous attempts have been made to avoid the above drawbacks and to find an improved alternative for this 3+9+15 construction.

Some attempts were directed towards providing a steel cord construction which was more economical to manufacture. An example is a 3+9+15
15 cord where all the layers have been twisted in the same direction. Another example is a so-called 1x27 compact cord, where all filaments have been twisted in the same direction with the same twisting step. These attempts lead to more economical cords but do not solve the problem of rubber penetration.

20 Other attempts were directed towards providing a steel construction with an improved rubber penetration.

An example is a $3 \times d_1 + 9 \times d_2 + 15 \times d_3$ cord where the three core filaments have a filament diameter d_1 which is greater than the filament diameter
25 d_2 of the intermediate layer filaments, and where the filament diameter d_2 of the intermediate layer filaments is greater or equal to the filament diameter d_3 of the outer layer filaments. The use of the thicker filaments in the center of the cord, lead to more space available for the layers and to unsaturated layers with spaces between the filaments.

30 Another example is 3+8+13 cord, i.e. a cord where the intermediate layer and the outer layer are no longer saturated with the maximum number of possible filaments. One or more filaments are omitted from

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the intermediate or outer layer and lead to spaces between the filaments so that rubber is able to penetrate.

5 Still another example are 3+9+15 cords where at least one filament in each layer, i.e. in the core, in the intermediate layer and in the outer layer are preformed so that they exhibit a wavy form. The wavy filament creates more space between the filament and the adjacent filaments and allows rubber to penetrate.

10 Following steel cord constructions are also widely used as reinforcement for the breaker or belt layer of a truck tire :

- 3x0.20 + 6x0.35
- 3x0.35 + 8x0.35.

15 These constructions, however, suffer from the same drawbacks as the 3+9+15 construction. Two twisting operations are required to manufacture the cord and complete rubber penetration is not obtained.

Summary of the invention.

20 It is an object of the present invention to avoid the drawbacks of the prior art.

It is another object of the present invention to provide an alternative cord for a 3+9+15 steel cord, a 3+6 cord or for a 3+8 cord.

It is still an object of the present invention to provide a steel cord with a full rubber penetration.

25 It is yet another object of the present invention to provide a steel cord which can be made in an economical way.

30 According to the invention there is provided a steel cord which comprises a first group and a second group. The second group is helically twisted around the first group with a cord twisting step. The first group comprises a first number of first steel filaments where first number ranges between three and eight. The second group comprises a second

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number of second steel filaments. The second number is equal to or, preferably, greater than the first number. The first filaments have a twisting step greater than 300 mm and are preferably untwisted (infinite twisting step). At least one of the second filaments is polygonally preformed. More than one of the second filament can be polygonally preformed. Preferably all the second filament can be polygonally preformed.

10 The technique of polygonal preforming is disclosed in US-A-5,687,557 and is incorporated herein by reference.

As will be explained hereinafter such a steel cord can be manufactured in one single twisting step.

15 The polygonal preforming of the second filaments gives an open structure to the steel cord and allows rubber or other matrix material to penetrate until the first group.

20 Preferably the second filaments are twisted around each other with a twisting step, hereinafter referred to as the group twisting step. This group twisting step is preferably equal to the cord twisting step. As will be explained hereinafter, this preferable embodiment may be obtained in one single step by means of a double-twisting apparatus.

25 In order to promote penetration of rubber or of another matrix material inside the first group of filaments or in order to obtain predetermined elongation features, at least one of the first filaments is preformed so that it has a wavy form. More than one of the first filaments and preferably all of the first filaments may be preformed so that they have a wavy form. This spatial wave form can be a helical form. However, this wavy form is
30 preferably a spatial wave form, i.e. the wave is not a planar wave but has dimensions outside a single plane. Preferably this spatial wave form has

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a first crimp and a second crimp. The first crimp lies in a plane which is substantially different from the plane of the second crimp.

Prior art documents JP-A-04-370283, JP-A-06-073672 and JP-A-07-

042089 all disclose steel cords which comprise two groups of steel filaments where one group is helically twisted around the other.

The JP-A-04-370283 steel cord has a first group of only two first filaments and a second group of N second filaments with N equal to two or three. The N second filaments are preformed so that they exhibit a wavy form.

The JP-A-06-073672 steel cord has a first group of two first filaments and a second group of two second filaments. The first filaments are preformed so that they exhibit a wavy form.

The JP-A-07-042089 steel cord first group of two first filaments and a second group of two or three second filaments. The first filaments are preformed so that they exhibit a wavy form so that the first filaments have the same length as the second filaments in the steel cord.

None of the JP-A-04-370283, JP-A-06-073672 or JP-A-07-042089 steel cords, however, can replace a 3+9+15, a 3+6 or a 3+8 construction with the same reinforcing effect.

In a preferable embodiment of the present invention, the first number of first filaments ranges from three to five and the second number of second filaments ranges from four to eight. For example the first number is equal to four and the second number is equal to six.

Brief description of the drawings.

The invention will now be described into more detail with reference to the accompanying drawings wherein

- FIGURE 1 schematically illustrates the way in which a steel cord according to the invention is manufactured ;

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- FIGURE 2 illustrates an actual cross-section of a steel cord according to the invention ;
- FIGURE 3 illustrates a principal cross-section of a steel cord according to the invention.

5

Description of the preferred embodiments of the Invention.

A steel cord according to the invention is preferably made as follows.

10 Starting product is a wire rod with a rod diameter ranging from 5.5 mm to 6.5 mm. The steel composition of this rod generally comprises a minimum carbon content of 0.60 % (e.g. at least 0.80 %, or at least 0.92 % with a maximum of 1.2 %), a manganese content ranging from 0.20 to 0.90 % and a silicon content ranging from 0.10 to 0.90 % ; the
15 sulphur and phosphorous contents are each preferably kept below 0.03 % ; additional elements such as chromium (up to 0.2 à 0.4 %), boron, copper, cobalt, nickel, vanadium ... may be added to the composition in order to minimize the amount of deformation needed to obtain a predetermined tensile strength.

20

The wire rod is dry drawn through a number of subsequent drawing dies until steel wire with an intermediate diameter is obtained. This dry drawing may be interrupted by an intermediate patenting treatment in order to obtain a metallic structure which is suitable to be drawn further.

25

At the intermediate diameter the steel wire is preferably coated with a metallic coating. The exact type of coating depends upon the eventual application. This coating may be a corrosion resistant coating such as zinc or a coating that promotes the adhesion to the matrix material such
30 as brass in the case of rubber, or a so-called ternary brass such as copper-zinc-nickel (e.g. 64% / 35.5% / 0.5%) and copper-zinc-cobalt

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(e.g. 64% / 35.7% / 0.3%), or a copper-free adhesion layer such as zinc-cobalt or zinc-nickel.

5 The steel wire with the metallic coating is further wet drawn until a final filament with a filament diameter. The exact value of this final diameter also depends upon the eventual application. Generally, the filament diameter ranges from 0.03 mm to 1.10 mm, more specifically from 0.15 mm to 0.60 mm, e.g. from 0.20 mm to 0.45 mm.

10 The final tensile strength of the steel filament may vary dependent upon the initial steel rod composition, the degree of deformation and the value of the filament diameter.
Preferably the steel filament has a high tensile strength. This is a tensile strength TS above the following minimum values :

15

$$TS > 2250 - 1150 \times \log d \text{ MPa}$$

where d is the filament diameter in mm.

As such steel filaments may have a tensile strength up to 4000 MPa and even higher.

20

The final twisting operation will be explained with reference to FIGURE 1. Starting from the right side of FIGURE 1, four first steel filaments 10 with a diameter of 0.38 mm are unwound from supply spools 12 and guided via guiding wheels 14, 16 and 18 towards a two pairs of toothed wheels 19 which give to the first steel filaments 10 a first crimp and a second crimp. The first crimp lies in a plane which is different from the plane of the second crimp.

25

The technique of double-crimping is disclosed in WO-A-99/28547.

30

The bundle 22 of double-crimped first steel filaments 10 is then guided via pulley 20 over a first flyer 24 of a double-twisting apparatus. The

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direction of bundle 22 is reversed over pulley 26, after which the bundle 22 enters the double-twisting apparatus centrally. During its travelling over flyer 24 and just thereafter, the bundle 22 of double-crimped first filaments 10 has received two twists.

5 Six second steel filaments 26 with a filament diameter of 0.38 mm are unwound from supply spools 28 inside the double-twisting apparatus. The six second steel filaments are guided over guiding wheels 30 towards a preforming device 31 which give to the second steel filaments 10 26 a polygonal preforming. The thus polygonally preformed second steel filaments 26 are further guided over distribution disc 32 towards a cord forming die 34 where the second steel filaments 26 come together with the bundle 22 of first steel filaments 10. The bundle 22 first steel filaments 10 and the second steel filaments 26 are then reversed via 15 pully 20 towards the second flyer 36 of the double-twisting apparatus. During their travelling over the second flyer 36 and just thereafter, the final invention steel cord 38 is formed : bundle 22 of first steel filaments 10 is untwisted and the second steel filaments 26 are twisted. The result is a steel cord 38 which meets following formula :

$$20 \quad 4 \times 0.38 + 6 \times 0.38 \quad 22/S$$

The group twisting step equals the cord twisting step and is about 22 mm.

25 Generally the group twisting step and the cord twisting step may vary between 30 times the filament diameter and 150 times the filament diameter, e.g. between 50 times and 70 times the filament diameter, although values outside these ranges are not excluded.

Table 1 hereunder summarizes some properties of this steel cord 38.

30 **Table 1**

Property	Dimension	Value
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-9-

Linear density	(g/m)	8.95
diameter	(mm)	1.64
Breaking load (bare)	(N)	2900
Breaking strength (bare)	(MPa)	2550
Breaking load (embedded)	(N)	2960
Breaking strength (embedded)	(MPa)	2600
Rubber penetration	(%)	100
Bending stiffness	(Nmm ²)	2135

FIGURE 2 shows an actual cross-section of a steel cord 38. The steel cord 38 has a first group of four first steel filaments 10 more or less parallel and untwisted. Spaces are available between the steel filaments 10 as a consequence of the double crimp. As a result rubber is able to penetrate inside the first group. A second group of six second steel filaments 26 is twisted round the first group. The six second steel filaments 26 have been polygonally preformed to allow rubber to penetrate through the second group and reach the first group.

FIGURE 3 shows schematically a 3+5 steel cord 38 according to the invention. Steel cord 38 has a first group of three first filaments 10 which have a spatial wave form so that spaces are created inside the first group. This is illustrated by means of the dotted lines around each first filament 10. A second group of five second steel filaments 26 is twisted around the first group. The second steel filaments 26 have been polygonally preformed so that spaces are created between the second filaments and between the first group and the second group.

Next to the embodiments illustrated in FIGURE 2 and in FIGURE 3, other embodiments of the invention steel cord are possible. Some examples are :

3 + 4

3 + 6

3 + 7

-10-

5 3 + 8
 4 + 5
 4 + 7
 4 + 8
 5 + 6
 5 + 7
 5 + 8
 6 + 6
 6 + 7
10 6 + 8

15 The filament diameter of the first and second steel filaments does not need to be the same. Even the filament diameter may vary inside a group, which means that the first group may comprise first steel filaments with a different diameter and that the second group may comprise second steel filaments with a different diameter.

20 Although the invention steel cord is particularly suitable for the reinforcement of the breaker or belt layer of truck tires, other applications where full rubber penetration or full impregnation with plastic are required or preferred, are possible.

CLAIMS

- 5 1. A steel cord comprising a first group and a second group, said first group being helically twisted around said second group with a cord twisting step, said first group comprising a first number of first steel filaments, said first number ranging between three and eight, said second group comprising a second number of second steel filaments, said second number being equal to or greater than said
10 first number, said first filaments having a twisting step greater than 300 mm, at least one of said second filaments being polygonally preformed.
- 15 2. A steel cord according to claim 1 wherein said second filaments are twisted around each other with a group twisting step.
3. A steel cord according to any one of the preceding claims wherein said group twisting step is equal to said cord twisting step.
- 20 4. A steel cord according to any one of the preceding claims wherein said second number is greater than said first number.
5. A steel cord according to any one of the preceding claims wherein at least one of said first steel filaments is preformed so that it has a
25 wavy form.
6. A steel cord according to claim 5 wherein said wavy form is a spatial wavy form.
- 30 7. A steel cord according to claim 6 wherein said spatial wavy form has a first crimp and a second crimp, the first crimp lying in a plane that is

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substantially different from the plane of the second crimp.

5 8. A steel cord according to any one of the preceding claims wherein
said first number ranges from three to five and wherein said second
number ranges from four to eight.

9. A steel cord according to any one of the preceding claims wherein
said first number is equal to four and wherein said second number is
equal to six.

10

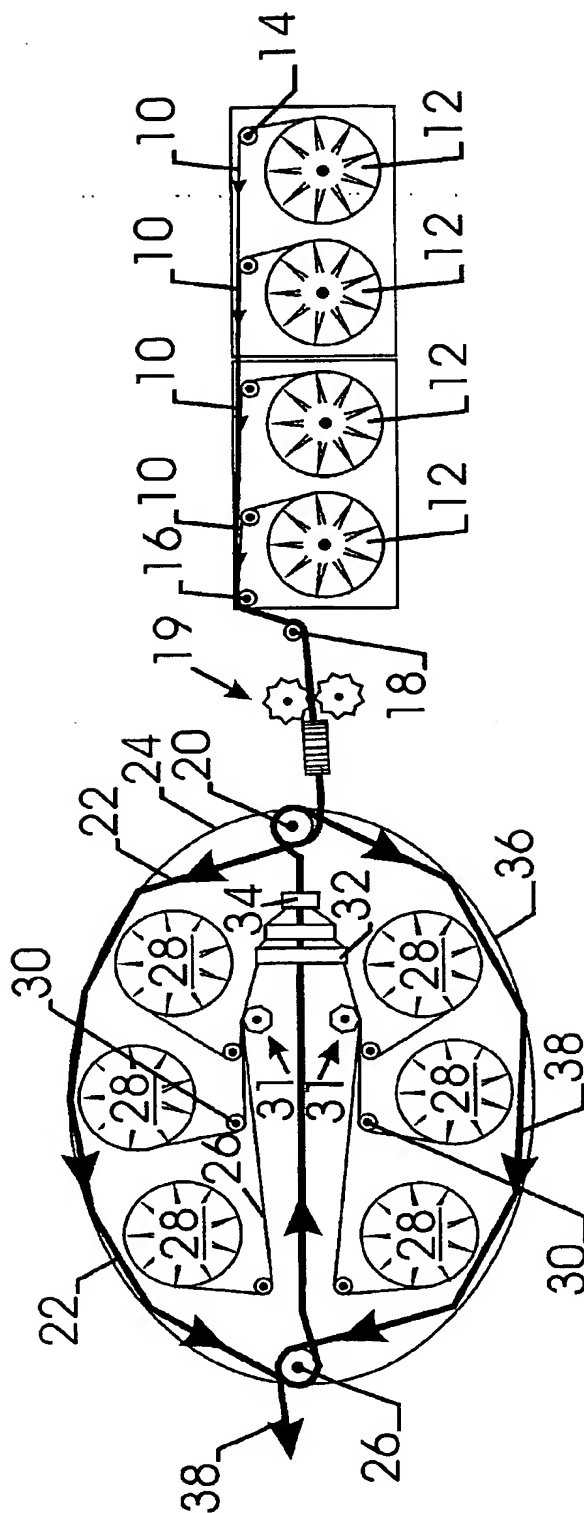


Fig. 1

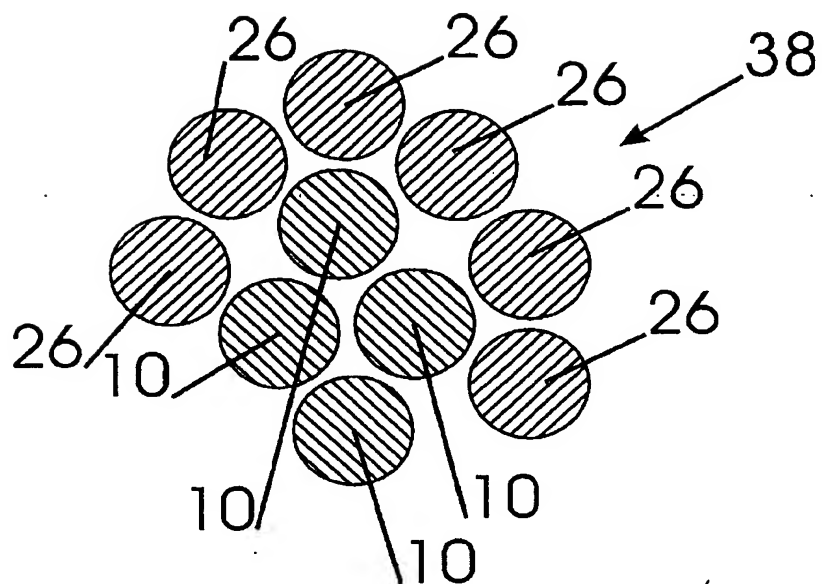


Fig. 2

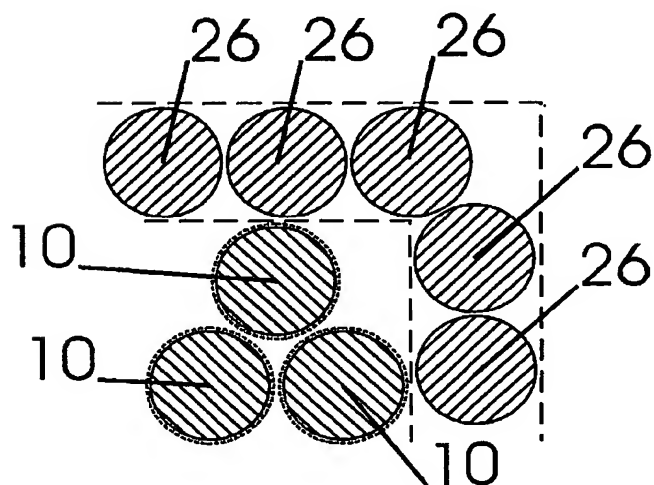


Fig. 3

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/03849

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 D07B1/06 D07B3/02 D07B7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 D07B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 098 251 A (N.V. BEKAERT S.A.) 17 November 1982 (1982-11-17) claims 1,2; figure 2 page 1, line 62 - line 94	1
A	---	2,3,8
Y	US 5 687 557 A (X. DE VOS; F VAN GIEL) 18 November 1997 (1997-11-18) cited in the application column 6, line 24 -column 7, line 59	1
A	---	1-5
	PATENT ABSTRACTS OF JAPAN vol. 17, no. 243, 17 May 1993 (1993-05-17) -& JP 04 370283 A (TOKYO SEIKO CO. LTD.), 22 December 1992 (1992-12-22) cited in the application abstract --- -/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/03849

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99 28547 A (N.V. BEKAERT S.A.) 10 June 1999 (1999-06-10) cited in the application abstract -----	5-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 02/03849

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 2098251	A	17-11-1982	NL 8102273 A	01-12-1982
			AT 384043 B	25-09-1987
			AT 181982 A	15-02-1987
			BE 893105 A2	08-11-1982
			BR 8202660 A	19-04-1983
			CA 1174565 A1	18-09-1984
			DE 3215638 A1	25-11-1982
			ES 265009 Y	01-06-1983
			FR 2505372 A1	12-11-1982
			IT 1147949 B	26-11-1986
			JP 1603152 C	29-03-1991
			JP 2029408 B	29-06-1990
			JP 57193253 A	27-11-1982
			KR 8801147 B1	01-07-1988
			LU 84130 A1	13-09-1982
			MX 159716 A	09-08-1989
			US 4408444 A	11-10-1983
			ZA 8202743 A	30-03-1983
US 5687557	A	18-11-1997	US 5878564 A	09-03-1999
			AT 185383 T	15-10-1999
			AU 683522 B2	13-11-1997
			AU 1242995 A	03-07-1995
			BR 9408321 A	05-08-1997
			CA 2171540 A1	22-06-1995
			CN 1133075 A ,B	09-10-1996
			CZ 9601735 A3	13-11-1996
			DE 69421090 D1	11-11-1999
			DE 69421090 T2	20-01-2000
			WO 9516816 A1	22-06-1995
			EP 0734468 A1	02-10-1996
			ES 2139878 T3	16-02-2000
			JP 9506679 T	30-06-1997
			PL 314529 A1	16-09-1996
			RO 116912 B1	30-07-2001
			RU 2137869 C1	20-09-1999
			SK 76296 A3	08-01-1997
			TR 28605 A	04-11-1996
			ZA 9409223 A	01-08-1995
JP 04370283	A	22-12-1992	NONE	
WO 9928547	A	10-06-1999	AU 1488699 A	16-06-1999
			BR 9812797 A	17-10-2000
			CN 1280639 T	17-01-2001
			WO 9928547 A1	10-06-1999
			EP 1036235 A1	20-09-2000
			JP 2001525501 T	11-12-2001
			TR 200001516 T2	21-11-2000
			US 6311466 B1	06-11-2001
			US 2002062636 A1	30-05-2002
			ZA 9810315 A	18-05-1999